Biodiversity & Ecosystems

Future of Agriculture Curriculum for Teaching Sustainability

Name: _____ Hour_____Date: _____

Date Packet is due:_____ Why late? _____Score: _____
Day of Week Date If your project was late, describe why

Overview: in this unit, you will be exploring how biodiversity enables ecosystems to provide services, and how levels of biodiversity and rates of biomass production relate to the resilience of an ecosystem. You will also be exploring the origins of biodiversity.

Main Questions

1. What is an ecosystem and how do the interactions of living species and nonliving resources enable an ecosystem to function?
2. How does the rate of biomass production relate to ecosystem function?
3. How does the level of biodiversity relate to ecosystem function?
4. How does the level of resilience of an ecosystem relate to its function?
5. What are ecosystem services and why are they vital to the existence of humans and other species?
6. How do genes and proteins relate to the levels of biodiversity in an ecosystem?
7. How do the genes and proteins of a species relate to the risk of extinction of that species?

Weekly Schedule

Monday:
- Introduction:
  - Option A: Bioreactor Ecosystems
  - Option B: Rocky Mountain Ecosystems

Tuesday:
- Nutshell Video & Notes
- Class discussion & revisions of explanations

Wednesday:
- Investigation: Meadow Simulation

Thursday:
- Review & Assessment

Friday:
- Weekly Reflection
- Career & Community Connections

Semester Schedule

Week 0: Introduction & Lab Safety

Atoms to Ecosystems

Week 1: Matter & Energy
Week 2: Cell Biology
Week 3: Biodiversity & Ecosystems
Week 4: Biodiversity & Habitats Lab
Week 5: Midterm Assessments

Causes of Extinction

Week 6: Extinction
Week 7: Habitat Loss
Week 8: Invasive Species
Week 9: Land & Water Pollution
Week 10: Atmospheric Pollution
Week 11: Overharvesting
Week 12: Midterm Assessments

Sustainable Societies

Week 13: Natural Resources Management
Week 14: Societies & Sustainability
Week 15: Individual Sustainability
Week 16: Personal Campaigns
Week 17: Personal Campaigns

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National Science Foundation WHERE DISCOVERIES BEGIN
KBS LTER Kellogg Biological Station Long-term Ecological Research
MICHIGAN STATE UNIVERSITY

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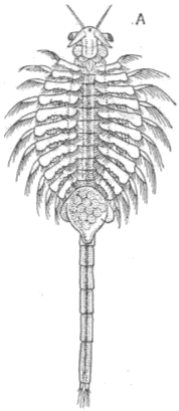
Day 1: Option A - Bioreactor Ecosystems

Introduction: In this activity, you will be using a sealed container to create a simplified ecosystem that will help you to better understand the relationships between living species and nonliving resources that enable an ecosystem to function. If you do not already have a bioreactor ecosystem set up, see the appendix for specific directions on how to do so. **Intro Video**: https://www.youtube.com/watch?v=f4SGo4Oe8Kc

An *ecosystem* is a term used to describe how living organisms interact with each other and with the nonliving components in a given area. Your bioreactor ecosystem is a tiny model that helps us to understand how much larger and more complicated ecosystems function. Your bioreactor ecosystem should contain only three kinds of organisms. The most obvious organisms are the brine shrimp. You should be able to see these tiny animals swimming throughout your ecosystem if you look closely. Less obvious are the phytoplankton. These are single-celled organisms that are similar to plants and can *photosynthesize* (or convert CO_2 and H_2O into glucose and oxygen using the energy of sunlight). Lastly, there are microbes in your bioreactor such as bacteria and microscopic fungi. These microbes will break down the biomass of the shrimp, phytoplankton, and other microbes when they die.



A brine shrimp individual.
Source: Wikimedia Commons

Directions: As a group, observe your bioreactor ecosystem and use your observations. As a group, address the questions below using your observations to guide your thinking. Use a notebook, dry erase board, or scratch paper to record your ideas. Answer as many questions as you can. Be prepared to discuss as a class.

Questions:

1. Briefly summarize all of the transformations of matter and energy that are occurring in this bioreactor.
    a. What forms of energy (light, motion, chemical, or heat) are present in this bioreactor ecosystem?
    b. What are some examples of energy transformation in this ecosystem?
    c. How is biomass being created from inorganic molecules in this bioreactor ecosystem?
    d. In what ways is biomass being converted back into CO_2 and H_2O in this ecosystem?
2. Your bioreactor ecosystem should be sealed so that air cannot be exchanged with the outside environment. Will your ecosystem run out of oxygen? Why or why not?
3. What is more important to the function of this ecosystem – the phytoplankton or the shrimp? Why?
    a. Could one exist without the other? Explain.
    b. Which do we need more of – the phytoplankton or the shrimp? Why?
4. *Biodiversity* is a term used to describe the variety of different species in an ecosystem.
    a. Is your bioreactor ecosystem very biodiverse? Explain.
5. A *resilient* ecosystem is one that could recover from a disturbance and still function.
    a. Do you think that this bioreactor ecosystem is resilient? Why or why not?
    b. How might the level of biodiversity in your ecosystem affect the resilience of that ecosystem?
6. *Ecosystem services* are the benefits that an ecosystem can provide. These can include nutrient cycling, oxygen production, water purification, and food production.
    a. How do you think that the level of biodiversity and level of resilience in your ecosystem affects the ability of your ecosystem to provide these services?

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Day 1: Option B – Rocky Mountain Ecosystems

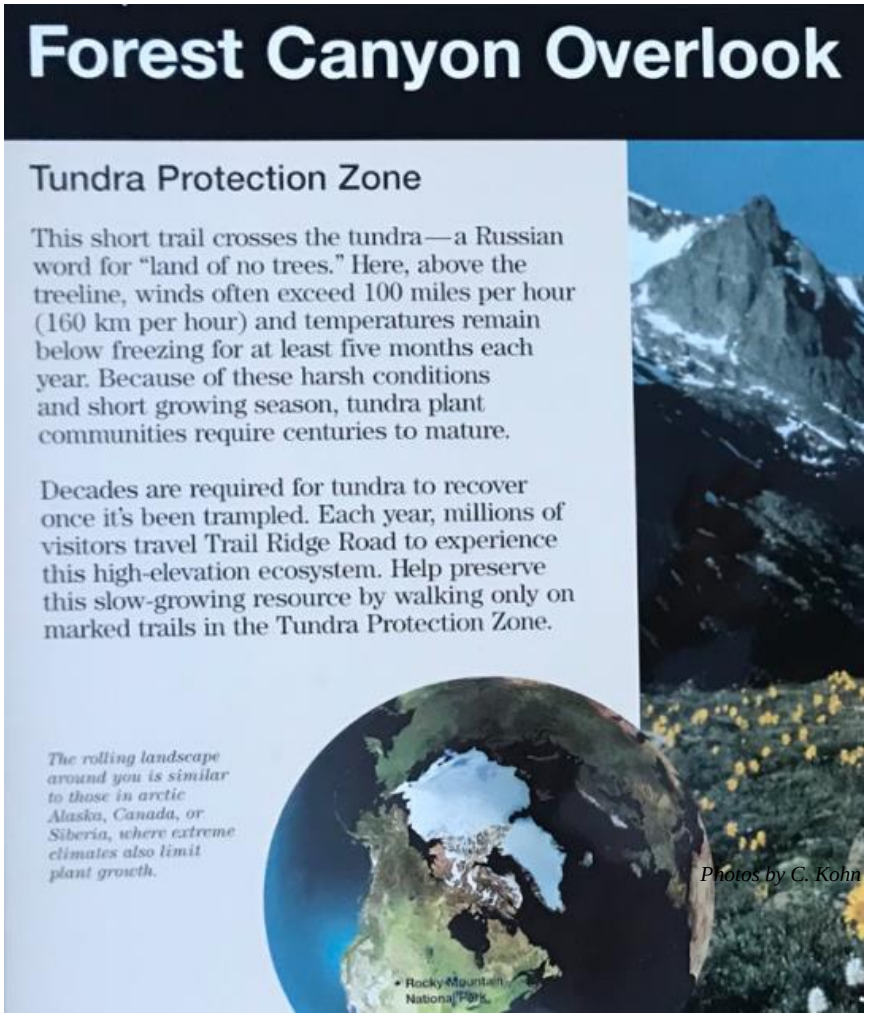
Overview: In this activity, your group will review data from actual experiments or scenarios in order to identify patterns and trends that you will use to develop an explanatory model. You will then compare your observations and explanations to those of other groups in order to check your accuracy and refine your explanatory model.
Introductory video: https://www.youtube.com/watch?v=f4SGo4Oe8Kc

Directions: Begin by reading the excerpt below. Then look at the data provided below. Use this information to answer the questions on the following page. If you are unsure about how to interpret the data, work with your group and seek help from your instructor if necessary. Your instructor will decide if you should record your answers using the space provided in this packet, a dry erase board, a digital document, or another option.

Introduction: Rocky Mountain National Park is found outside of Denver, CO. This park contains some of the highest alpine (mountain) peaks in the United States. The landscapes found in this park are at such a high altitude that they resemble ecosystems in Alaska and Siberia.

As hiking trails in this park reach the *treeline* (or the altitude at which trees are unable to grow), posted signs frequently warn visitors of the importance of staying on the trails while in the tundra. These ecosystems are especially vulnerable to damage caused by hikers who leave the trail. These signs warn hikers that damage caused by leaving the trail will cause decades, or even centuries of ecological damage in alpine ecosystems. This is very different from an ecosystem like a deciduous forest, where within a few years or even months, most damage will be repaired by ecological processes.

The images on the right were taken in Rocky Mountain National Park. Read the text from these trail signs and then proceed to the questions on the next page.



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Directions: Read the accompanying information on the previous page before completing these questions. Your instructor may decide to have you complete your responses using a format other than this worksheet.

1. How do these alpine tundra ecosystems in the Rocky Mountains differ compared to most other ecosystems with regard to their ability to recover from damage?

   _____

2. Why do the tundra ecosystems in the Rocky Mountains take so much longer to recover compared to other ecosystems? Work individually or in teams to come up with ideas. Record all your ideas below.

   _____

   _____

   _____

   _____

   Which of these seems like it is the most accurate? Circle it and explain why you think it's most accurate.

   _____

   _____

   _____

3. Briefly summarize how each of the following considerations in the tundra ecosystem compare to conditions in deciduous forest (*leafy tree*) ecosystems. The first item has been completed as an example.

   a. Temperature: _____ *Tundra ecosystem are generally much colder.* _____

   b. Liquid Precipitation: _____

   c. Sunlight: _____

   d. Rates of Photosynthesis: _____

   e. Rates of Biosynthesis: _____

   f. Capacity for Biomass Production: _____

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4. With your responses for the previous question in mind, how do you think that the capacity for supporting living organisms differs between a deciduous forest ecosystem and this tundra ecosystem?

What evidence and/or logic supports this conclusion? Please explain in detail:

5. *Biodiversity* is a term used to describe the variety of different species in an ecosystem. How do you think that the biodiversity compares between a tundra and a forest ecosystem? Explain.

6. A *resilient* ecosystem is one that could recover from most disturbances and still function. Do you think that this tundra ecosystem is resilient? Why or why not?

7. How might the level of biodiversity in your ecosystem affect the resilience of that ecosystem?

8. *Ecosystem services* are the benefits that an ecosystem provides. These include nutrient cycling, oxygen production, water purification, and food production. How do you think that the level of biodiversity and level of resilience in this ecosystem affects the ability of this ecosystem to provide services? Explain.

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Day 2: Notes & Discussion

Introduction & Directions: In this activity, you will begin by watching a short video about ecosystems. This will help to clarify some of the questions you may have had yesterday. After the video, you will look at a short slideshow presentation that will provide you with specific information about how ecosystems function. Your instructor may decide to deliver the presentation as a classroom lecture or they may allow you to read the notes individually or in small groups (depending on your previous experience and capabilities with this content). After you have watched the video and finished with the slideshow, you will work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign your group to answer specific questions if time is limited.*

URL Links
YouTube Video: https://www.youtube.com/watch?v=j3z6iKKynWE
Alternate video: https://youtu.be/eGG7hyx_HlA

Slideshow Presentation: https://www.factsnsf.org/uploads/1/4/0/9/14095127/2020-9-20_facts_cell_biology_w_questions.pdf (*or visit www.factsnsf.org and use the menu bar*)

Discussion Questions:

1. Briefly summarize how living species such as plants, animals, and decomposers interact with each other and the non-living components of their environments. Include the following terms: producers, consumers, CO_2, H_2O, sunlight, plants, animals, decomposers.
2. Why do environments that are sunnier, warmer, and wetter typically have larger numbers of species than environments that are darker, colder, and drier? How does this relate to the 10% Rule?
3. Briefly summarize the three kinds of biodiversity. Then define *ecosystem resilience* and explain how biodiversity and ecosystem resilience are related.
4. What are *ecosystem services*? What are examples of the four kinds of ecosystem services? How do biodiversity, ecosystem resilience, and ecosystem services affect each other?
5. Why should humans care about biodiversity, ecosystem resilience, and ecosystem services? How do these concepts affect the daily lives of people? What happens to people if these items are impaired?
6. Are some species in an ecosystem more valuable than others? Use the terms *producers* and *keystone species* in your answer.
7. How does the function of a human-managed ecosystem differ from that of a naturally-occurring ecosystem? What are the advantages and disadvantages of having human-managed ecosystems?
8. All species exhibit different traits. Why? Briefly summarize the source of the different traits exhibited by living species. In your answer, include the following: genes, proteins, DNA.
9. Where does biodiversity come from? Explain how new species emerge by describing the changes to DNA that occur as a result of mutations, natural selection, and evolution.
10. Why do some species disappear? Explain how extinctions occur as a result of environmental changes.

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Warm temperatures, sufficient moisture, and adequate levels of sunlight increase rates of photosynthesis.	Greater rates of photosynthesis lead to more production of biomass via biosynthesis.	Increased levels of plant biomass allow for more living organisms to exist.	More living organisms enables more biodiversity to emerge through mutations & natural selection.	More biodiversity results in greater ecosystem function and ecosystem resilience.
During <u>photosynthesis</u>, light energy is used to combine H_2O and CO_2 into glucose and oxygen molecules. This light energy is transferred to chemical energy in high-energy bonds of glucose. Warmer, wetter, and sunnier conditions allow for greater rates of photosynthesis.	The glucose produced during photosynthesis can be used for either... 1. <u>Cellular respiration</u>: the energy in glucose is transferred to ATP. 2. <u>Biosynthesis</u>: the glucose is used to produce more plant tissue (<u>biomass</u>).	Most biomass is converted to H_2O and CO_2 when consumed due to cell respiration and the <u>10% rule</u>. Because all species acquire their biomass directly or indirectly from plants, the more plant biomass that exists, the greater the variety of species that exist (<u>biodiversity</u>).	The <u>proteins</u> in the cells of living organisms create their visible traits. Proteins are assembled based on <u>genes</u> in a cell's <u>DNA</u>. <u>Mutations</u> change genes & proteins. Beneficial mutations improve the survival of some individuals (<u>natural selection</u>) and can result in new species (<u>evolution</u>).	Greater levels of <u>biodiversity</u> allow an ecosystem to provide more and more <u>ecosystem services</u>. This improves <u>ecosystem function</u>. More biodiversity also reduces the <u>fragility</u> of an ecosystem and increases <u>ecosystem resilience</u>.

Day 3: Lab Activity – Meadow Simulation

Introduction: you will be completing two activities today. The first involves re-visiting your ideas from Day 1 and see if you are better capable of addressing them. In particular, pay attention to whether or not your answers might have changed as a result of new information from Day 2. The second activity requires you to use a computer simulation to explore how changing populations of producers and consumers affects the stability and composition of a hypothetical ecosystem. Your instructor may choose to demonstrate how this program works for the entire class before letting you work in your groups.

Directions:

1. Begin by re-observing your bioreactor ecosystems and re-visiting the questions on page 2.
    a. Briefly address each question as a team.
    b. Are you better able to answer these questions now than the first time you tried?
    c. How have your answers changed since you first saw these questions?
2. Next visit the meadow computer simulation at https://carbontime.bscs.org/sites/default/files/simulations/eco-simulation/index.html (*or use an internet search engine and search for "Carbon TIME Meadow Simulation" if the URL does not work*).
3. Use the worksheet on the following pages to record your responses.
4. Complete the activity using the instructions in the simulation worksheet. If your instructor provides you with hard copies of the worksheet, complete the answers on the worksheet copy provided to you. If you are accessing the worksheet digitally, ask your instructor if written or oral answers are required.
5. After completing the meadow simulation activity, address the questions below as a group. Be prepared to provide your answers during a follow-up class discussion.

Class Discussion Questions:

1. What patterns did you notice in the amount of fox, rabbit, and grass biomass at the completion of each trial? How would you explain these patterns given what you know about ecosystems?
2. If a disease were to occur in this ecosystem and caused the number of grass plants to drop by 75%, what would happen to other species in this ecosystem? Why? How does this relate to the 10% rule?
3. If there were multiple species of grass, rabbits, and foxes, would biodiversity in this ecosystem increase or decrease? Would it be more or less resilient? Would the ecosystem services increase or decrease?
4. What would be necessary to occur in order for more species of foxes, rabbits, and grass to emerge over time? Summarize how this ecosystem could become more biodiverse via mutations & natural selection.
5. Could this ecosystem function without plants? Could it function without animals?
6. Are there any human activities that could *decrease* the biodiversity/ecosystem services/resilience of this habitat? Are there any human activities that could *increase* the biodiversity/services/resilience?

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Day 3: Meadow Simulation Worksheet

Used with permission. Original: https://carbontime.bscs.org/sites/default/files/ecosystems/worksheets_assessments/2.2_Meadow_Simulation_Worksheet.pdf

Introduction: The Meadow Simulation allows you to set the initial mass of organic matter in grass, rabbits, and foxes and observe the changes in the organic mass of the populations over a 100-year period.

Directions: Go to the following website: https://carbontime.bscs.org/sites/default/files/simulations/eco-simulation/index.html. Set the initial mass for each population by dragging the sliders or typing in the boxes. Note that the maximum initial organic mass for each population is 1000 kg. Click the start arrow in the top right corner of the screen to run the simulation. On the simulation screen, use the buttons on the stopwatch at the bottom to pause the simulation (middle button), move ahead one year (right button), or to start a new run (left button).

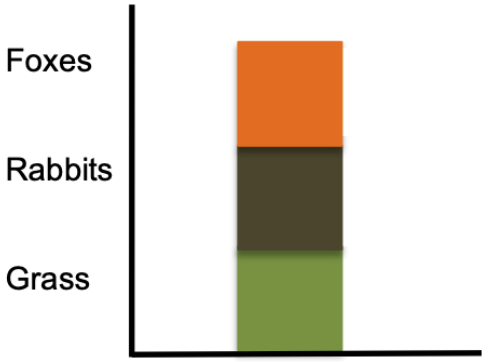
1. Trial 1 – Set the following initial conditions, run the simulation, and complete the table below. (Note: After a run you can click on the graph to make a line appear. Drag the line to the year that you want to record the data for, and it will appear in the data table below the graph).

   Fox Organic Mass: t = 0: *500 kg* t ~ 50: _____ t = 99: _____

   Rabbit Organic Mass t = 0: *500 kg* t ~ 50: _____ t = 99: _____

   Grass Organic Mass t = 0: *500 kg* t ~ 50: _____ t = 99: _____

2. Below is a organic mass diagram representing the initial conditions for trial 1. Sketch the final organic mass diagram for trial 1 (Notes: you can always get back to the lab book that records the data for each run by clicking the left button of the stopwatch to start a new run).



Initial Trial 1 organic mass
(as percent of ecosystem total)

Final Trial 1 organic mass
(as percent of ecosystem total)

3. Why do you think that the organic mass diagram changed the way that it did in trial 1? Explain your reasoning.

_____

_____

_____

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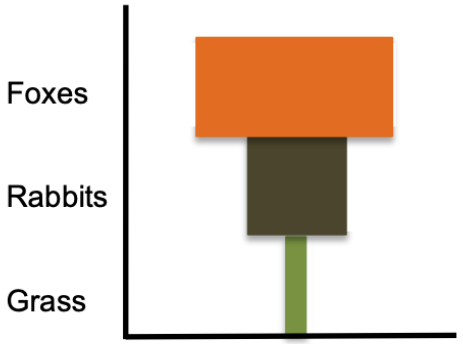
4. Trial 2 – Set the following initial conditions, run the simulation, and complete the table below.

Fox Organic Mass: t = 0: *1000 kg* t ~ 50: _____ t = 99: _____

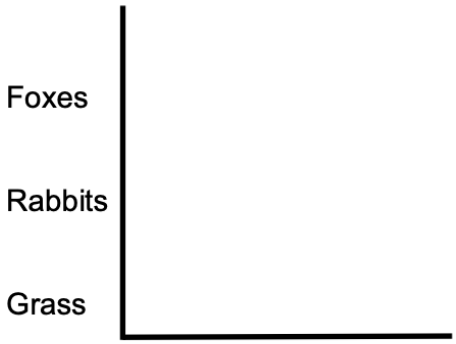
Rabbit Organic Mass t = 0: *500 kg* t ~ 50: _____ t = 99: _____

Grass Organic Mass t = 0: *100 kg* t ~ 50: _____ t = 99: _____

5. Sketch the final organic mass diagram for Trial 2.



Initial Trial 2 organic mass
(as percent of ecosystem total)



Final Trial 2 organic mass
(as percent of ecosystem total)

6. Why do you think that the organic mass diagram changed the way that it did in trial 2? Explain.

_____

_____

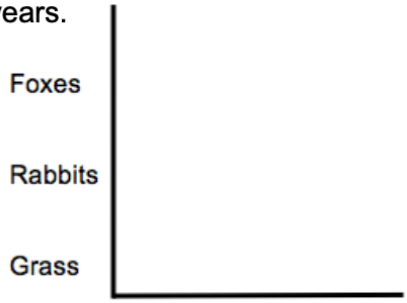
_____

7. Use the simulation to determine the maximum organic mass of foxes that the meadow ecosystem can support. Record your data for the initial final organic mass for each population in the table below. Attach another sheet of paper for additional trials if necessary.

	Trial 1 Initial	Trial 1 Final	Trial 2 Initial	Trial 2 Final	Trial 3 Initial	Trial 3 Final	Trial 4 Initial	Trial 4 Final
Foxes								
Rabbits								
Grass								

8. Record the data and draw the organic mass diagram for the conditions that resulted in the highest organic mass in the fox population at the end of 100 years.

	Initial	Final
Foxes organic mass		
Rabbits organic mass		
Grass organic mass		



Final organic mass
(as percent of ecosystem total)

Day 4: Review & Assessment

Directions: you will begin by reviewing the unit objectives in your small groups. For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. After a few minutes of review, your instructor will lead a whole-class review. This is your chance to ask any questions you still might have about the concepts in this unit. Begin with anything you ranked as a "1".

After you have completed the unit review, you will be taking an individual multiple choice quiz and/or a group short answer quiz. These quizzes may be graded in class to help you better understand the question and the correct answer.

Unit Objectives:

1. What is the definition of an ecosystem? What is required for something to be an ecosystem?
2. What are producers and what are consumers in an ecosystem? How does the presence of consumers and producers relate to the function of an ecosystem?
3. How does the climate of an area and the rate of biomass production affect the amount of producers and consumers that can exist in an ecosystem? How does this relate to the 10% rule?
4. What is biodiversity? How can you determine the level of biodiversity in an ecosystem?
5. What are ecosystem services? How does the level of biodiversity relate to the amount of ecosystem services that can be provided? Why should humans care about ecosystem services?
6. What is ecosystem resilience? How does the level of biodiversity relate to the resilience of an ecosystem? Why should humans care about ecosystem resilience?
7. What is a keystone species? How does the presence of a keystone species relate to ecosystem function, ecosystem services, and ecosystem resilience?
8. What is a human managed ecosystem? How does the function of a human managed ecosystem differ from a naturally-occurring ecosystem? How does the level of biodiversity and ecosystem services of a human managed ecosystem differ from a naturally-occurring ecosystem?
9. What is DNA? What are genes? What are proteins? What are mutations? How do these items relate to the visible traits of an organism? How do these items relate to the levels of biodiversity in an ecosystem?
10. How can more biodiversity be created through mutations, natural selection, and evolution?
11. What factors increase biodiversity in an ecosystem? What factors decrease biodiversity in an ecosystem?

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Day 5: Career Connections

Directions: to begin this activity, you will form small groups (ideally, 3-4 individuals). These groups could either be your assigned lab groups from this week OR you could find 2-3 other individuals who have career interests that are similar to yours. Your instructor will inform you which option you will be using to form your groups.

Once you have formed your groups, address the following questions as a team.

1. Try to summarize everything that you have learned so far in this course within your group. Try to identify the common themes, major ideas, and most important concepts from the content you have learned.

2. Try to get a sense of how each person in the group feels about these concepts. Is there anything that anyone still doesn't completely understand? Is there anything that anyone maybe disputes or disagrees with? Is there anything that seemed particularly surprising or noteworthy to anyone?

3. Using a notebook, whiteboard, or scratch paper, list what you think are the most important ideas and concepts that you have learned so far. Aim to have at least 5 or 6 ideas written down. It is ok to have more than this.

4. As a group, try to determine how these ideas relate to the careers you intend to go into. Specifically…
   a. How might your daily activities in this future career be affected by these concepts?
   b. How might the decisions you make as part of this career be influenced by these ideas?
   c. How has your intended career area changed over time as a result of our understanding of these concepts? How might it continue to change in the future?

5. In the coming units, the focus will be on how to minimize the losses to biodiversity as a result of human activity. In other words, you will be learning about the causes of extinction and how the rate of extinctions can be reduced by adjusting how humans use natural resources.
   a. How do you think your career might *decrease* biodiversity and *increase* the likelihood of causing extinctions?
   b. How do you think your career could be changed in order to *increase* biodiversity and *decrease* the likelihood of causing extinctions?

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Biodiversity & Ecosystem Services Indiv. Quiz

Name: _____ Hour_____ Date:_____ Score:_____ /___

Directions: This quiz should be completed on an individual basis. A 3x5 notecard with handwritten notes can be used on this quiz.

1. **A plant is sealed in a jar with an adequate amount of moisture and soil. Microorganisms such as bacteria and fungi are present in the soil at appropriate levels. The sealed jar with the plant, soil, and microorganisms is placed in a well-lit location. Is this an ecosystem?**
    a. No it is not – an ecosystem requires animals to function.
    b. Yes it is – an ecosystem is just a bunch of living organisms.
    c. No it is not – an ecosystem cannot function in an isolated environment.
    d. Yes it is – this has living species interacting with each other and with the nonliving substances inside the environment of this jar.

2. **Which of the items in this jar could be considered a <u>producer</u> that is able to create biomass from inorganic molecules?**
    a. The soil bacteria & fungi b. The plant c. The soil minerals d. None of the above e. All of these

3. **Which of the items in this jar could be considered a <u>consumer</u>, which is not able to create biomass from inorganic molecules and must consume other organisms?**
    a. The soil bacteria & fungi b. The plant c. The soil minerals d. None of the above e. All of these

4. **Which of the items in this jar could be considered a <u>non-living component</u>?**
    a. The soil bacteria & fungi b. The plant c. The soil minerals d. None of the above e. All of these

5. **Which of the following would decrease the biomass production in this jar?**
    a. Reducing the temperature b. Reducing the sunlight c. Reducing the moisture d. All of these

6. **Would it be feasible for the number of consumers to constantly be greater than the number of producers in an ecosystem?**
    a. Yes – because nutrients and energy cycle in an ecosystem, the amount of matter and energy in that ecosystem stay constant no matter how many producers or consumers exist.
    b. No – because only 10% of the matter and energy of a producer goes into the body of a consumer when eaten, so there must be many more producers than consumers.
    c. No – the amount of producers and consumers must be equal for an ecosystem to function.
    d. Yes – everything that is alive is carbon-based and carbon can neither be created nor destroyed.

7. **A lawn consists of a single species of grass as well as soil microorganisms and an occasional animal. A nearby prairie consists of multiple species of grass as well as various species of flowers in addition to animals and soil microorganisms. Which has greater biodiversity?**
    a. The lawn b. The prairie c. You cannot tell from this information alone.

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8. **Would the lawn or the prairie have greater ecosystem resilience and function?**
    a. The lawn b. The prairie c. You cannot tell from this information alone.

9. **Would the lawn or the prairie have greater ability to provide ecosystem services?**
    a. The lawn b. The prairie c. You cannot tell from this information alone.

10. **Which of the following best describes ecosystem resilience?**
    a. The benefits that an ecosystem can provide.
    b. The diversity of living organisms in an environment.
    c. The ability of a habitat or ecosystem to recover from a threat or disturbance.
    d. The species that an ecosystem depends upon more so than other species.

11. **Which of the following best describes ecosystem services?**
    a. The benefits that an ecosystem can provide.
    b. The diversity of living organisms in an environment.
    c. The ability of a habitat or ecosystem to recover from a threat or disturbance.
    d. The species that an ecosystem depends upon more so than other species.

12. **Which of the following best describes a keystone species?**
    a. The benefits that an ecosystem can provide.
    b. The diversity of living organisms in an environment.
    c. The ability of a habitat or ecosystem to recover from a threat or disturbance.
    d. The species that an ecosystem depends upon more so than other species.

13. **A corn field, a livestock ranch, and a suburban yard are all examples of human managed ecosystems. Which of the following best describes a human managed ecosystem?**
    a. Human managed ecosystems maximize biodiversity and ecosystem services so that humans can be provided with as many benefits as possible from an ecosystem.
    b. Human managed ecosystems reduce biodiversity and focus on providing one kind of ecosystem service at the expense of other ecosystem services.
    c. Human managed ecosystems would continue to function exactly the same with or without human intervention.

14. **This is a stretch of DNA with the information needed to assemble a functional bodily molecule.**
    a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

15. **This is the kind of molecule that does most of the work of the body and is responsible for most of the visible traits in an organism (such as eye color, size, etc.).**
    a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

16. **This is the term for a change to DNA that may result in changes to an organism's traits. It is usually harmful but can sometimes result in a more beneficial trait.**
    a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

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17. **This is the process in which species with traits more appropriate and beneficial for their environment produce more offspring than those without those traits.**
    a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

18. **This is the process in which an entire species changes over time (and possibly becomes a new species) due to beneficial changes to its DNA.**
    a. Protein b. Gene c. Natural Selection d. Mutation e. Evolution

19. **Which of the following would NOT increase biodiversity?**
    a. Warmer, wetter environment b. Beneficial mutations c. Rapid environmental changes

20. **The lower the biodiversity, the ___ the ecosystem services & the ___ the ecosystem resilience.**
    a. Greater, greater b. greater, lower c. lower, greater d. lower, lower

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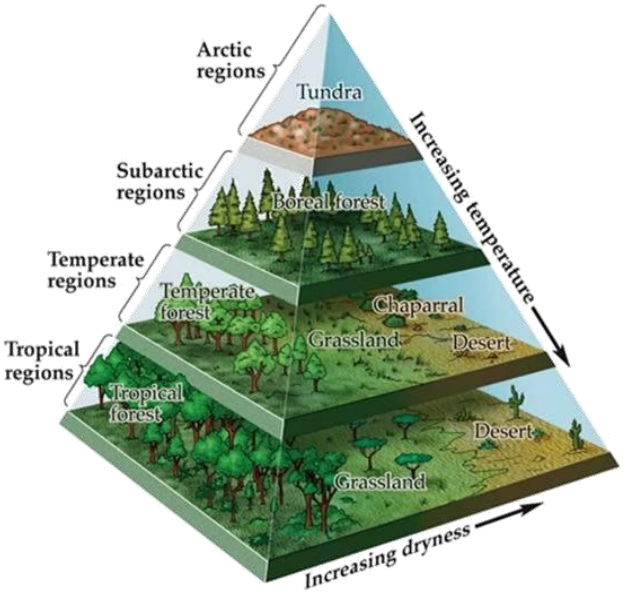
Biodiversity & Ecosystem Services Group Quiz

Names (F&L): _____

_____Hour_____Date:_____Score:_____/___

Directions: This quiz should be completed in your assigned groups. A 3x5 notecard with handwritten notes can be used on this quiz. Each person should take turns writing an answer. Those not writing should be actively working together to create their group's answer. Those who are not actively involved in answering every question may be asked to complete this quiz alone. Record the writer's name after each question.

1. Some ecosystems (such as tropical rainforests) have immense amounts of biodiversity. These ecosystems tend to provide large amounts of ecosystem services and tend to be very resistant to disruptions and ecological threats. On the other hand, some ecosystems (such as cold desert regions such as the Antarctic and mountain tops) have very little biodiversity, provide very few ecosystem services, and are very susceptible to threats and disturbances. Using the image to the right, explain why this is the case. In your answer, be sure to address all of the following: *1) biomass production; 2) 10% rule; 3) producers & consumers.*



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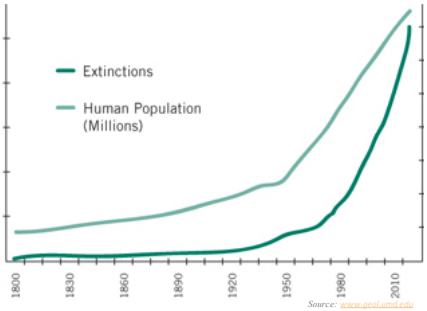
2. Currently the rate of extinction is roughly a thousand times faster than the normal rate of extinction. Species are now going extinct at a rate that is over 100 times faster than the rate at which the dinosaurs went extinct. Is this a problem for humans? How might this unprecedented rate of extinction affect the day-to-day lives of human beings? In your answer, include the following: 1) biodiversity; 2) ecosystem services; 3) types and examples of ecosystem services; 4) ecosystem resilience.



Writer's Name:

3. Unusually warm springs in the Pacific Ocean have caused algal blooms that have poisoned sea otters, reducing their populations. Sea otters are a keystone species in these ecosystems. How might reduced sea otter populations affect the ocean ecosystems in which they are found? In your answer, define *keystone species* and summarize the importance of these kinds of species.

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4. Human managed ecosystems differ from naturally occurring ecosystems with regard to their levels of biodiversity, the amount of ecosystem services provided, and the resilience of these ecosystems (i.e. their ability to function without human intervention). Briefly summarize how and why human managed ecosystems are different from naturally occurring ecosystems in regard to biodiversity, ecosystem services, and resilience. Use examples in your answer.

Writer's Name:

5. Where does biodiversity come from? How could more biodiversity be created? Include the following: 1) DNA; 2) genes; 3) proteins; 4) traits; 5) mutations; 6) natural selection; 7) evolution.

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Appendix: Setting up your Bioreactor Ecosystems

Introduction: Bioreactor Ecosystems use a very simple model of an ecosystem to help students understand the relationships between different species and nonliving resources that enable an ecosystem to function. In this case, brine shrimp (*Artermia salina*) and phytoplankton (*Tetraselmis sp.*) represent the two primary living species. The phytoplankton serve as the basis of the food chain as the photosynthesizing producers, while the brine shrimp are the consumers. Bacteria and other microbes naturally present in the water serve as the decomposers.

Materials: FACTS bioreactor (or a sealed 1000 ml Pyrex beaker or glass jar), artificial seawater (e.g. *Instant Ocean* and unchlorinated water such as spring water), phytoplankton solution (e.g. *Kent Phytoplankton*), brine shrimp (e.g. *Decapsulated Brine Shrimp Eggs*), pipette or syringe, stir plate or aerator.

Directions: To set up your ecosystem, start the following steps at least a couple of days prior to the class in which this set-up will be used.

1. Obtain a clean FACTS bioreactor (or sealable jar or beaker).
2. Add 400 ml of artificial seawater (this can be created using a product such as *Instant Ocean*; follow the instructions on the packet).
3. Add 1 ml of the phytoplankton to the bioreactor.
4. Add a small pinch of the brine shrimp cysts (eggs) to the bioreactor (if possible, add the eggs to an aerated flask of water a day or two earlier so that they are hatched and ready).
5. Place bioreactor in a sunny, well-lit location at constant room temperature (or place a fluorescent bulb near the bioreactors to provide a source of light).
6. Aeration and/or gentle stirring may be necessary initially to enable the ecosystem to get started.
7. Bioreactor ecosystems will need to be checked daily to ensure that they have sufficient levels of algae and shrimp. Add more algae if it cannot be detected. Add more shrimp cysts if none can be seen.

Amazon Prime Purchasing Keywords

- Artificial Seawater: “Instant Ocean Sea Salt for Marine Aquariums, Nitrate & Phosphate-Free”
- Phytoplankton: Kent Phytoplex Plankton
- Brine Shrimp: Decapsulated Brine Shrimp Eggs (Artemia Cysts) (2 oz.)

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Appendix: Data Dives / Case Studies

Overview: Data Dives are exercises in which students are presented with data from experiments or scenarios, and are asked to identify trends and develop explanatory models in a process that is very similar to what actual scientists do on a regular basis. This particular Data Dive is more of a Case Study due to the fact that it deals more with an authentic scenario than data from an experiment.

Directions: Students should consider the data or scenario in their assigned groups. They should work with their group members to make sense of the information provided and try to determine the conclusions that can be drawn from it. Students may struggle with this, especially in their first attempts and particularly if your students have limited experience reading graphs and data tables. It may be necessary for you to project the data onto a large screen and guide students by explaining the steps that you would use to make sense of what is being reported. This may be difficult; just like explaining the steps of tying your shoes can be challenging because you rarely have to think about it, it can be exceptionally challenging for someone who is scientifically literate to identify the thought processes that they use to make sense of data. It may be helpful to jot down your ideas in advance and have them ready prior to the start of this class.

Students are likely to struggle to varying extents. That is ok! Be sure to float from group to group to assist. Be sure to remind group members to help each other out. It might ideal to assign groups with a mix of abilities. Encouraging struggling students to work with their better-prepared peers, and conversely, encouraging high performing students to advance their abilities by working with individuals with different skill sets helps to prepare students for the kinds of situations they will encounter in their careers and personal lives.

Plan to allow for about 15-20 minutes to introduce the activity and review how to interpret this information with your students. About a third to half of the class period should be reserved for allowing students to work in their individual groups. The remaining time should be reserved for intergroup or whole-class discussion so that students can engage in scientific debate and argumentation.

It would a good idea to remind students that the term *argumentation* is used differently between scientists and the general public. While argumentation generally has a negative connotation (such as a “heated argument”), argumentation among scientists is generally very good-natured and polite. The goal is not to “win” an argument but rather to expand the understanding of the phenomenon by all involved. Often scientists on opposing sides of an issue will both change their stance as a result of the improved understanding that results from engaging in argumentation. Similarly, students should not be trying to disprove each other or prove that they have the “right” answer. Rather, students should be examining the differences in their conclusions, the manner in which each conclusion was reached, and the similarities and agreements that exist among different conclusions.

Students may reach a conclusion that is not entirely supported by evidence. The temptation may be to point out errors in their reasoning. However, when students are struggling, they are also likely improving their abilities in evidence-based reasoning, which is one of the most important goals of this kind of instruction. Try to resist the urge to correct student errors; rather, try to probe their understanding and challenge them to re-examine the evidence to check the validity of their conclusions and the conclusions of other groups. Consider using the 9 Talk Moves (next page) to support productive classroom dialogue.

Remember – students should re-visit their explanations and models repeatedly over the course the week. If they don’t get it right on the first try, they will have more opportunities to do so.

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Goals for Productive Discussions and Nine Talk Moves

Goal: Individual students share, expand and clarify their own thinking

1. Time to Think:

Partner Talk

Writing as Think Time

Wait Time

2. Say More: "Can you say more about that?" "What do you mean by that?" "Can you give an example?"

3. So, Are You Saying…?:
"So, let me see if I've got what you're saying. Are you saying…?" (always leaving space for the original student to agree or disagree and say more)

Goal: Students listen carefully to one another

4. Who Can Rephrase or Repeat?

"Who can repeat what Javon just said or put it into their own words?" (After a partner talk) "What did your partner say?"

Goal: Students deepen their reasoning

5. Asking for Evidence or Reasoning:

"Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?" "Is there anything in the text that made you think that?"

6. Challenge or Counterexample:

"Does it always work that way?" "How does that idea square with Sonia's example?"
"What if it had been a copper cube instead?"

Goal: Students think with others

7. Agree/Disagree and Why?:

"Do you agree/disagree? (And why?)" "Are you saying the same thing as Jelya or something different, and if it's different, how is it different?" "What do people think about what Vannia said?"
"Does anyone want to respond to that idea?"

8. Add On:

"Who can add onto the idea that Jamal is building?"
"Can anyone take that suggestion and push it a little further?"

9. Explaining What Someone Else Means:

"Who can explain what Aisha means when she says that?" "Who thinks they could explain in their words why Simon came up with that answer?" "Why do you think he said that?"

Source: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

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Appendix: Review and Asssessment

Introduction: In this section, we will discuss strategies to guide your students during review and assessment for a vocabulary-intensive unit.

While recent reforms to science education (as outlined by the NRC's *K12 Framework* and NGSS) minimize the emphasis on having students learn vocabulary, we have found that we cannot completely eliminate vocabulary from ecological instruction for a number of reasons. Most importantly, we have found that in order for students to sufficiently engage in reasoning and sense-making about ecological phenomena, they need to have an appropriate language with which to develop explanations and solutions.

However, in the FACTS curriculum, we view vocabulary as a *means to an end* and not as a central objective to the curriculum. In other words, we don't care very much whether students have memorized the definitions of terms, but whether they can accurately use those terms to describe and understand phenomena, and ultimately create evidence-based arguments, explanations, and solutions. We view vocabulary as part of a "sense-making toolkit" that enables students to organize their reasoning and argumentation.

As such, we recommend that you provide students with opportunities to practice mastering the vocabulary in this course while also recognizing that mastery of vocabulary is a secondary objective in these units. This means that assessing vocabulary can work as a formative assessment but is not ideal by itself as a summative assessment. The primary goal of this curriculum is to enable valid evidence-based reasoning and sense-making, and your summative assessments should reflect this.

There are a few strategies you might considering adopting to support these objectives:

- While multiple-choice assessments are provided in the weekly packets, we take the stance that these options should not be used by themselves as a final summative assessment.
    - You might consider assigning this as optional homework, allowing students to use a 3x5 card with handwritten notes, and/or assigning completion points in lieu of scores based on the percent correct.
- Teachers have also created hybrids of the multiple choice and short answer assessments, selecting some questions from each option. Their experiences suggest that the multiple-choice assessments help to prepare students for the more intellectually rigorous short answer questions.
- You might also consider having a space on a chalkboard/dry-erase board for publicly posting course vocabulary or hanging a large sheet of paper and adding vocabulary and definitions if students start to struggle.
- Teachers have also used vocabulary practice as an option for a bell-ringer activity, using options such as short, ungraded online quizzes to start class.

You as the instructor are best positioned to decide what will be most effective for your classroom. Feel free to use or disregard these suggestions as you see fit. However, we do strongly recommend that you avoid positioning memorization of vocabulary as one of the primary objectives of this course, and instead emphasize valid reasoning and sense-making about ecological phenomena as your top priority.

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